Citation:

Westerterp-Plantenga MS, Lejeune MP, Nijs van Ooijen M, Kovacs EM. High protein intake sustains weight maintenance after body weight loss in humans. *Int J Obes Relat Metab Disord.* 2004 Jan; 28 (1): 57-64.

PubMed ID: 14710168

Study Design:

Randomized Controlled Trial

Class:

A - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To investigate whether addition of protein may improve weight maintenance by preventing or limiting weight regain after weight loss of 5-10% in moderately obese subjects.

Inclusion Criteria:

- In good health
- Non-smokers
- Not using medication
- At most moderate alcohol users
- Overweight and moderately obese with a body mass index (BMI) between 25 and 25kg/m^2.

Exclusion Criteria:

None.

Description of Study Protocol:

Recruitment

Not described.

Design

Randomized controlled trial with a parallel design.

Dietary Intake/Dietary Assessment Methodology

None described.

Blinding Used

None.

Intervention

- A very low-energy diet intervention was prescribed to all subjects for four weeks. The aim was a body weight loss of at least 4 kg over four weeks
- After the weight loss period, subjects entered a weight maintenance period. Subjects were divided into two identical groups, stratified by gender, BMI, age, eating behavior and resting energy expenditure. Subjects from both groups visited the University with the same frequency and received the same attention from the researchers and the same amount of counseling by the dietitian
- To one of the groups, 48.2g additional protein per day was provided as one sachet of a meal replacer (Modifast) per day (17g protein) plus two sachets of protein (31.2g protein) to be dissolved in water resulting in two vanilla drinks. Subjects were required to consume the meal replacer and one protein drink as part of their ad libitum lunch and one protein drink in the afternoon. This was intended to result in 18-20% of energy from protein
- There was no placebo used for the group that did not receive the extra protein.

Statistical Analysis

- Effects of the protocol including additional protein intake over time on the parameters measured were compared with effects of the protocol followed without additional protein on these parameters using ANOVA repeated measures
- When appropriate, differences between groups were analyzed using factorial ANOVA or a Student's T-test
- Relationships of changes in parameters over time with changes in leptin were analyzed using regression analysis
- Statistical significance was set at $P<0.05$.

Data Collection Summary:

Timing of Measurements

Measurements were taken at baseline, after four weeks of weight loss, and after three months of weight maintenance.

Dependent Variables

- Body weight and BMI were determined using measured height and weight taken by study personnel. Measurements were taken at baseline, four weeks, one, two and three months
- Waist circumference was measured by study personnel
- Body composition was determined using the deuterium dilution technique
- Attitude toward eating was assessed using the Three Factor Eating Questionnaire and the Herman Polivy Questionnaire
- Post-absorptive appetite profile, hunger and satiety were determined using 100mm visual analogue scales in the morning before breakfast
- Blood parameters of plasma glucose, free fatty acid concentration, insulin, glycerol concentrations, triacylglycerol levels and B-hydroxybutyrate were measured using a fasting blood sample
- Resting energy expenditure and substrate oxidation were measured using an open-circuit

ventilated hood system
- Physical activity and total energy expenditure were measured using a triaxial accelerometer for a one week period, and TEE was calculated by multiplying REE by physical activity level. Energy intake was calculated as TEE plus energy storage (based on body composition).

Independent Variables

Compliance to additional protein intake was assessed using 24-hour urine samples and analyzed nitrogen content.

Control Variables

Not applicable.

Description of Actual Data Sample:

- *Initial N:* 150
- *Attrition (final N):* 148
- *Mean age:* Protein group 44 years; Control group 45 years
- *Ethnicity:* Not applicable
- *Other relevant demographics:* Not applicable
- *Anthropometrics:*
  - Weight was 85kg in both groups at baseline
  - Mean BMI was 29kg/m^2 in both groups at baseline
- *Location:* The Netherlands.

Summary of Results:

Body Weight Loss Period

Both groups lost a significant amount of weight (6.4kg) during the four-week weight loss phase, with no differences between the groups.

Weight Maintenance Period

- Percentage of energy from protein was 18% in the higher protein group, compared to 15% in the control group
- Satiety ratings before breakfast were significantly higher in the higher protein group, compared to the control group ($P<0.05$)
- After three months, percentage of weight regain (17% vs. 37%) was significantly lower in the higher protein group compared to control ($P<0.05$). After three months, BMI was significantly lower in the higher protein group compared to control (27 vs. 28kg/m^2; $P<0.05$)
- Changes in REE and core body temperature did not differ significantly between the groups
- Increase in triacylglycerol and leptin were significantly lower in the higher protein group ($P<0.05$). Increases in glucose, insulin and decreases in B-hydroxybutyrate, glycerol and free fatty acids did not differ between groups.

Author Conclusion:

Overweight to moderately obese men and women who were consuming 18% energy as protein

regained less weight, 1kg during three months after 7.5% body weight loss over four weeks, compared to the 2kg regain that their counterparts who consumed 15% energy as protein.

Reviewer Comments:

- *Subjects in the control group did not receive a placebo, making it unclear whether there may have been a placebo effect in the group receiving daily protein supplements*
- *Dietary intake was not measured, making it difficult to determine whether subjects were consuming 18% and 15% energy from protein respectively, and whether energy intake or other dietary intake values also differed significantly between the groups.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes

Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes

2.4.	Were the subjects/patients a representative sample of the relevant population?	Yes
3.	**Were study groups comparable?**	Yes
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	Yes
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	Yes
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	N/A
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	No
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	Yes
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	No
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	No
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	Yes
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	N/A

5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	Yes
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	N/A
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	No
6.6.	Were extra or unplanned treatments described?	No
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	Yes
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	No
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes
7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	No
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes

8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	Yes
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	No
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes